Incorporating Risk and Reliability into Decisions:

Risk-informed Decision Making

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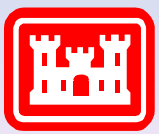

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Risk in Planning

- It's largely deterministic
- Process relies on a single most likely alternative future forecast
  - Desire for single right answer
  - Often anchored in present
  - Adversarial--legitimate differences in views of uncertain future

Risk in Planning

- Principles and Guidelines
  - Economic efficiency of investment decision approach
  - Choose the plan that most reasonably maximizes net NED consistent with protecting environment
  - Identify and describe areas of risk and uncertainty to provide knowledge of the degree of reliability of the estimated benefits and costs and of the effectiveness of alternative plans.

Risk Guidance in P&G

- Assumption that risk arises from benefits and costs
  - Economic risk
- No explicit consideration of human health and safety or other non-monetary risks
  - Only inferential in flood damage reduction
    - Number of units by activity

Traditional Response to Risk

- Risk management guidance embedded within engineering design guidance
- Risk presumed to be “managed” by engineering design
  - Freeboard on levees and dams
  - Factors of safety
  - Underkeel clearance design criteria
  - Channel width design criteria
  - Probable maximum flood spillways

Traditional Risk Management

- Manage risk to increase certainty of engineering performance
- Presumption that increased certainty only added to costs
  - No addition to benefits
- Viewed as necessary to achieve claimed benefits

Traditional Risk Management

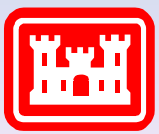
- Risk management was implied attempt to provide some level of assurance of project performance
  - Value of assurance not quantified
- Risk assessment and risk management bundled within engineering
  - Viewed as technical decision

Modern View of Risk Management

- Needs to be separate from risk assessment
- Answers the question what should be done about the risk
  - Incorporate issues of effectiveness, cost, and generally opens decision
  - Attempts to determine the best way of addressing the risk

Existing Corps Risk Policies

- ER 1105-2-100—Planning Guidance Notebook
  - The planner's primary role in dealing with risk and uncertainty is to characterize to the extent possible the different degrees of risk and uncertainty and to describe them clearly so that decisions can be based on the best available information
  - The assessment of risk and uncertainty in project evaluation should be reported and displayed in a manner that makes clear to the decision-maker the types and degrees of risk and uncertainty believed to characterize the benefits and costs of the alternative plans considered.



Existing Corps Risk Policies

- ER 1130-2-500 & EP 1130-2-500 (1992)—Major Rehabilitation
  - Requires reliability based benefit-cost analysis to evaluate investment in major rehabilitation
  - Life-cycle evaluation
- EC 1105-2-205 (1992) & ER 1105-2-101(1996)-Risk-based Analysis For Evaluation Of Hydrology/ Hydraulics And Economics In Flood Damage Reduction Studies
  - Includes residual risk requirement

Existing Corps Risk Policies

- 1110-2-1155--Dam Safety Assurance Program
  - Hydrologic or Seismic deficiency
  - Criteria based
    - Base safety condition for hydrologic
    - Maximum credible earthquake (MCE)
    - Operating basis earthquake (OBE)
  - Other causes—major rehabilitation framework
- New Dam Safety
  - Moving toward risk analysis approach covering all causes

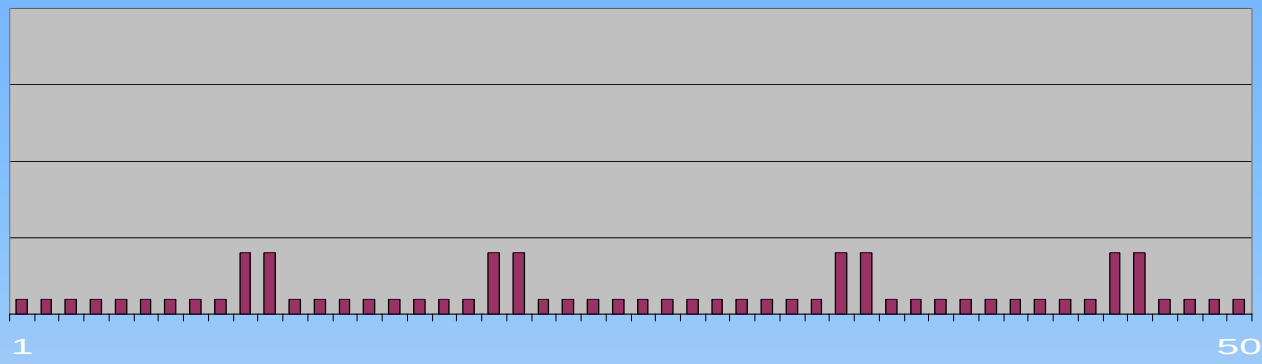
Major Rehabilitation Background

- Analytical Requirements
  - Equivalent framework to planning studies

Major Rehabilitation Guidance

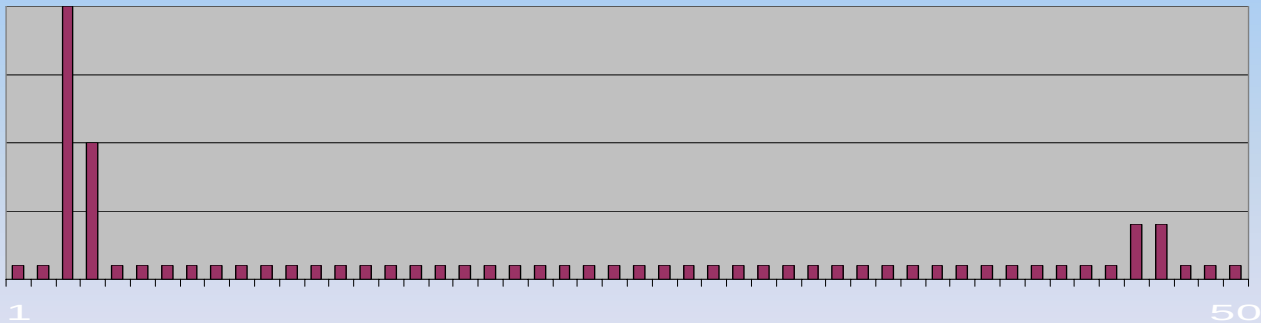
- Major Points
  - Objective of the Analysis
  - Base Condition
  - Analysis of Alternatives

NED Cost Timeline



Base condition:

fix-as-fail

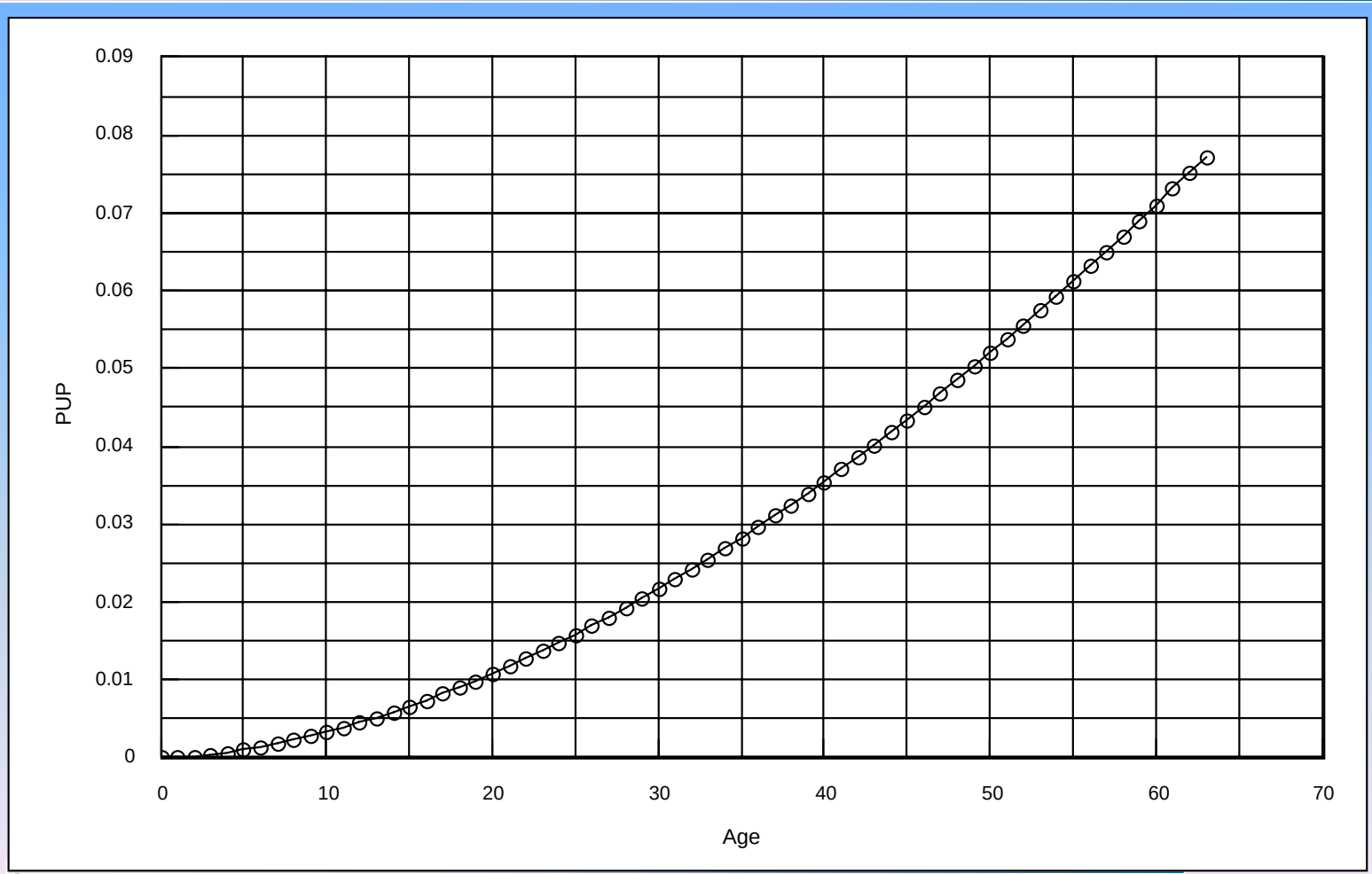


Alternative:
Rehabilitate then
fix-as-fail

PUP Functions

- Probability of Unsatisfactory Performance
  - Instantaneous probability of component not performing as designed
  - Typically related to age or number of operations
  - Unsatisfactory performance must have measurable consequences

Example PUP Function



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Analysis Must Answer

1. Why are we doing this now?
2. What are the consequences of not doing this now?
3. Which project or component is in the most critical condition?
4. Which alternative rehabilitation strategy is the best?

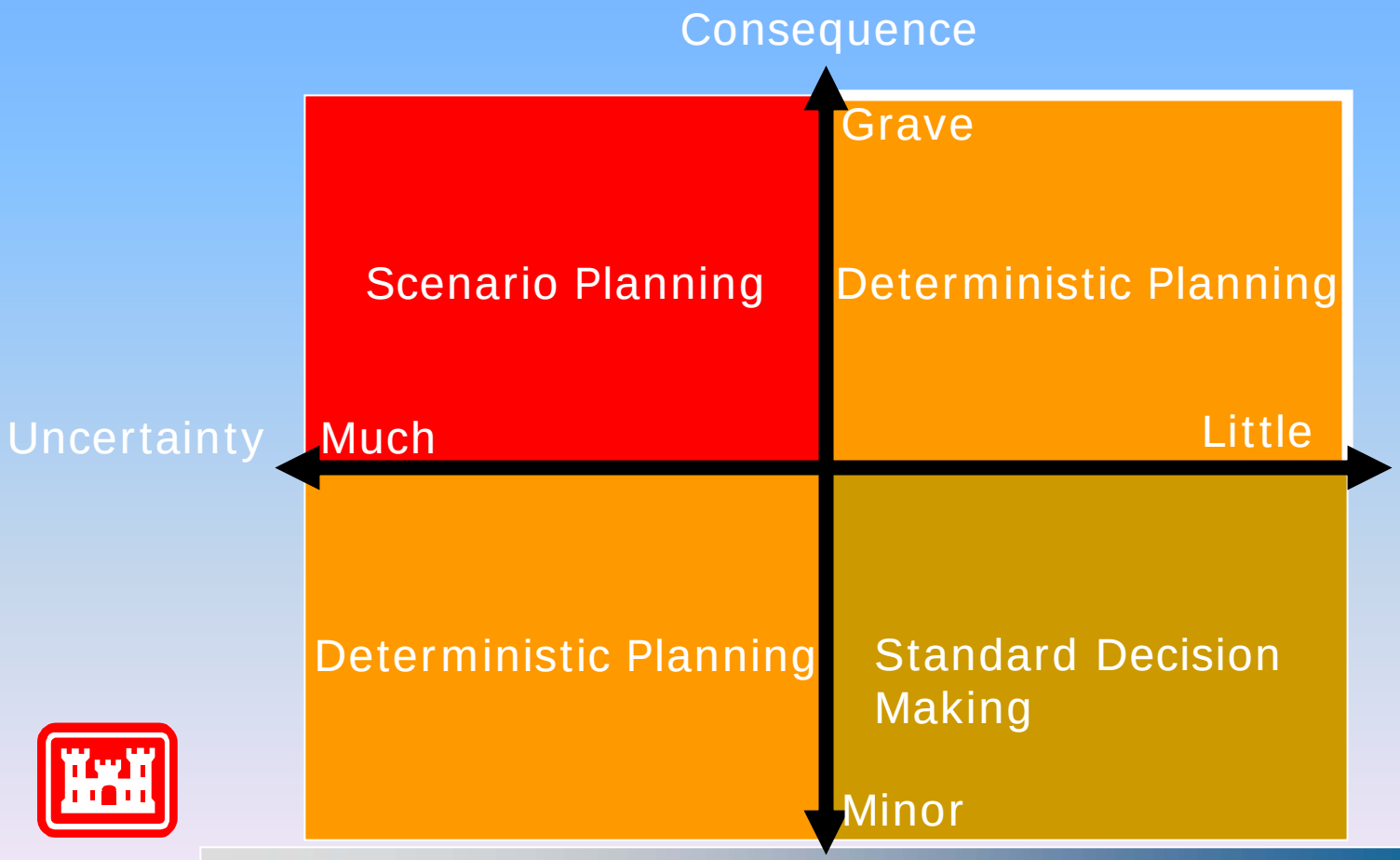
Objective of the Analysis

- Determine the Economically Efficient Rehabilitation Strategy
  - Commensurate values that differ in terms of risk, monetary values, and timing

Scenario Planning as Approach to Decisions under Uncertainty

- Developed in second half of 20th century
- Result of failure of traditional planning
  - Deterministic view of future
  - Forecasts were wrong

When to Use Scenario Planning



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Scenario Approach

- Much uncertainty
  - ID drivers
- Identify future scenarios
- Use scenarios to aid formulation
- Maybe be scenarios (assumptions) in “with” plan that influence plan performance
  - Response to plan may be uncertain
- Do analysis

  (good science)
- Evaluate plans against all scenarios

Multiple Scenarios Analysis Ex.--Mt. St. Helens

- Problem
  - Sediment deposited in rivers will increase residual flood risk
  - Choose least cost method to maintain level of flood protection
- Key uncertain variable
  - Forecast volume and timing of eroded sediment
  - “The Sediment Budget”

Multiple Scenarios Analysis Ex.--Mount St. Helens

- Alternatives Considered
  - Single and multiple sediment retention dams
  - Dredging
  - Combinations

Multiple Scenarios Analysis Ex.--Mount St. Helens

- Approach
  - Evaluate each alternative for each scenario based on
    - economic cost
    - environmental values and impacts
    - risk
    - uncertainty in sediment yield relative to breakeven yield

Mount St. Helens Decision Matrix

I	II	III
If DM believe	***If DM believe***	***If DM believe***
Sed. budget will be < 0.64 E and/or	Sed. budget will be > E and/or	There is uncertainty in sed. budget but expect it will be < 0.64 E and/or if they are uncertain about natural recovery but feel it will be substantial and/or
SRS is Env. less damaging than dredging	SRS is Env. less damaging than dredging	Dredging is env. less damaging than SRS
If DM wish to	***If DM wish to***	***If DM wish to***
Assure certainty offered by SRS solution and/or	Assure certainty offered by SRS solution and/or	
Minimize risk from low prob. single or sequential events and/or	Minimize risk from low prob. single or sequential events and/or	Maintain greater flexibility to adjust plan to the sed. realized over time
Emphsasize EQ	Maximize NED and EQ elements	

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Mount St. Helens Decision Matrix [cont.]

I	II	III
If DM are willing to	***If DM are willing to***	***If DM are willing to***
Forego NED for EQ and/or Forego NED for risk aversion		Risk temporarily reduced levels of protection from low probability single or sequential events
Forego opportunity to adjust response to realized sediment		Forego certainty of SRS solution
Risk financial loss of NED if Sed. <0.64 E	Risk financial loss of NED if Sed. <0.64 E	Risk financial loss of NED if Sed. >0.64 E
Minor dredging in out-years	Dredge or build stage(s) in out-years	Commit to long-term management of a dredging program
Budget for larger outlay in initial years	Budget for larger outlay in initial years	Commit to budgeting for dredging costs on an annual basis
DM would select	***DM would select***	***DM would select***
125-foot SRS	125-foot SRS and plan for and build a second above 125-foot SRS in out-years or a 150-foot SRS	Dredging

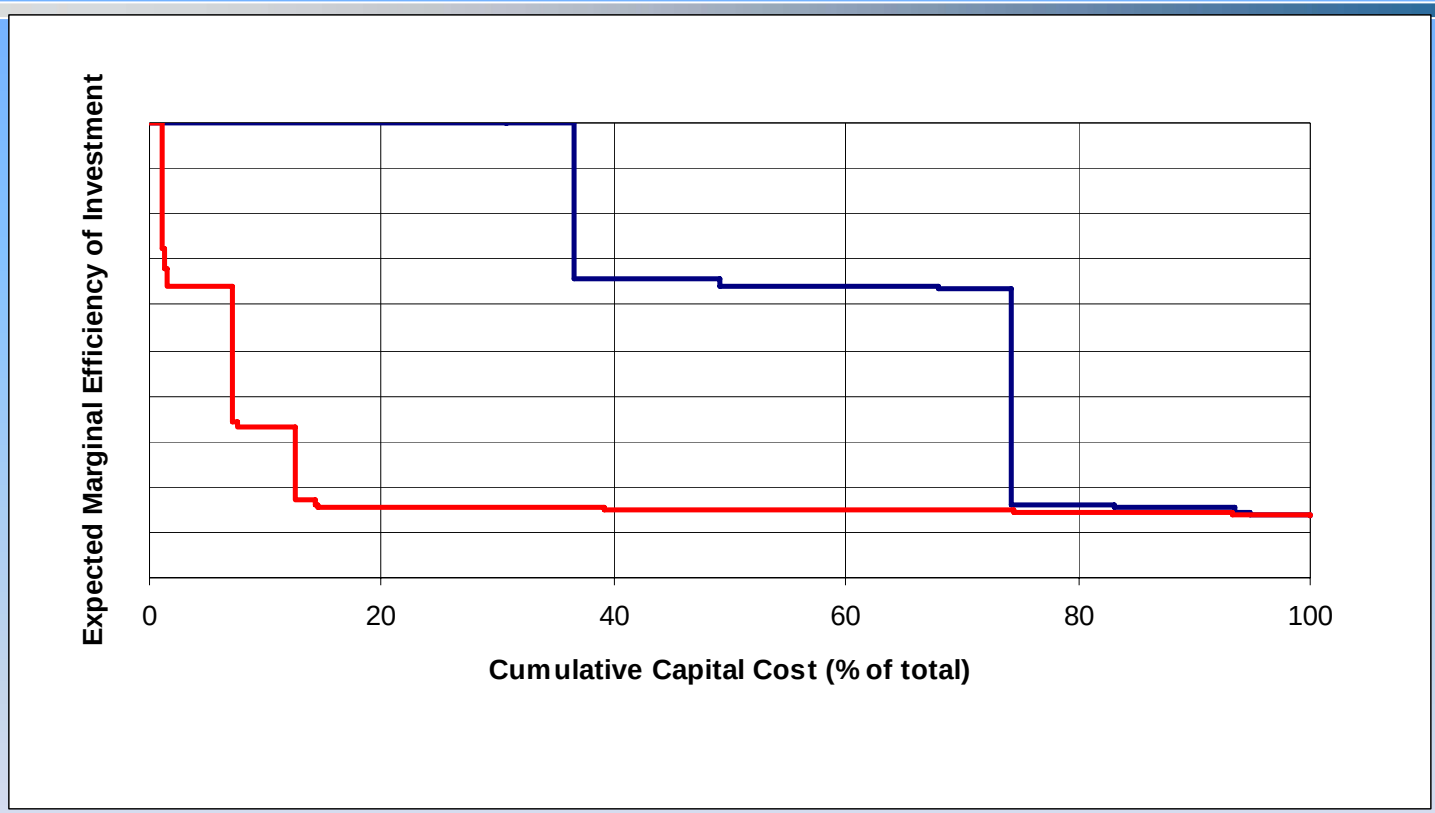
Risk-informed Decision Making

- Develop and use risk information to aid decisions
  - Decision metrics and rules developed by decision makers
  - Use risk assessment approach to develop science-based values of risk metrics

Risk-informed Decision Making

- Needs to convey information on residual risks
- Show risk metric values under all scenarios
- Develop useful tradeoff information
  - Incremental changes in metrics

Risk Reduction Prioritization



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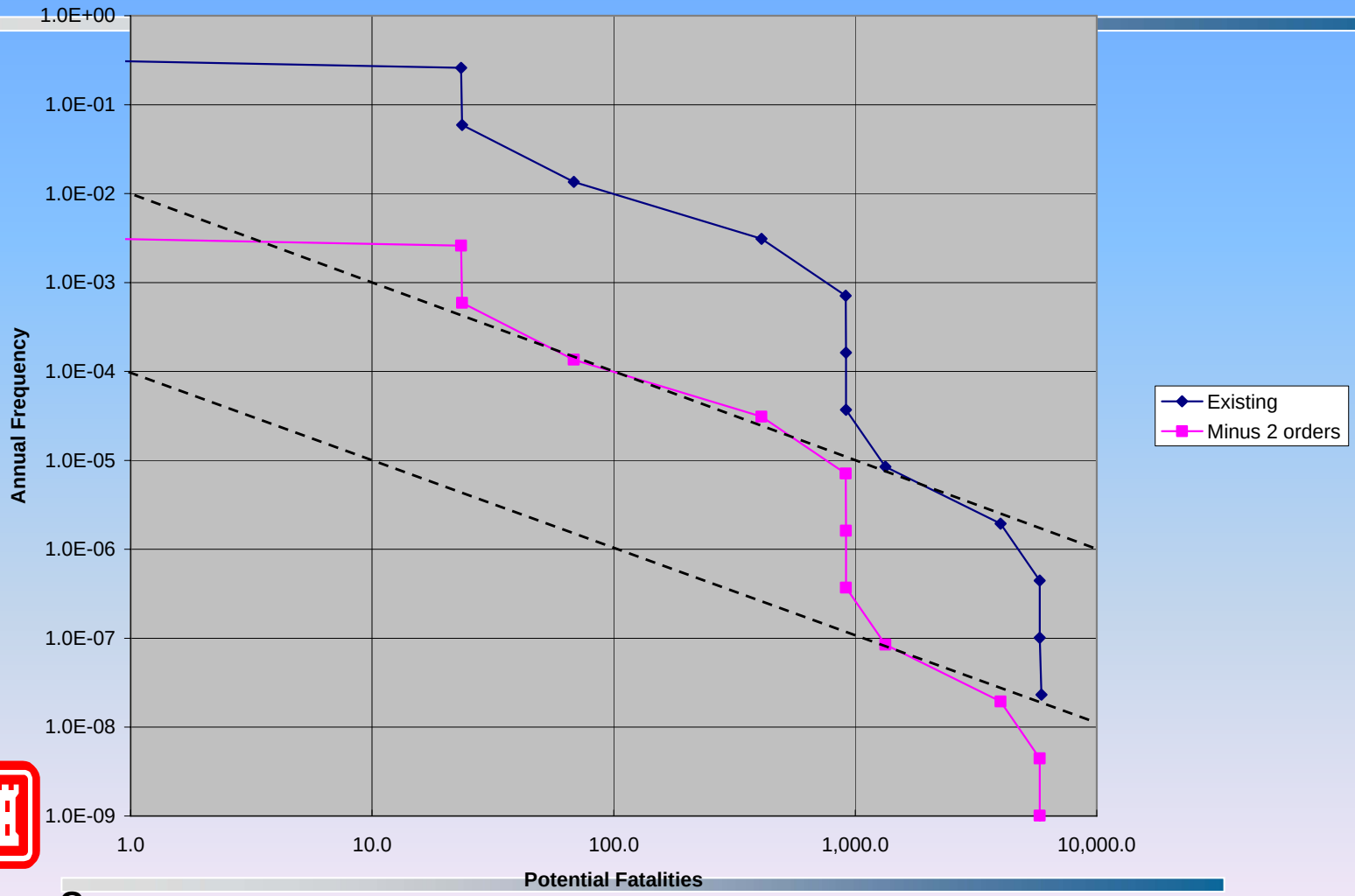
Notional Risk Reduction



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Possible Metrics

- Economic risk
  - Expected Net economic benefits
- Life safety risk
  - Tolerated residual risk
- Combined
  - Net cost per statistical life saved

Take Away Points

- Decisions on risk are NOT solely the responsibility of engineers
- Need to consider consequences of risk-bearing
- Not all risks can or need to be quantified to help inform decision makers
- Risk management requires involvement of stakeholders
- Major rehabilitation approach applicable to wide variety of investment decisions
- Engineering approach may not be able to reduce risks to tolerable levels at acceptable cost